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SURGICAL TREATMENT OF AORTIC ANEURYSMS*

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Aneurysm of the aorta is a serious disease causing distressing symptoms and ultimate death from rupture. Prognosis in aortic aneurysm depends to some extent upon the location and nature of the lesion, but in general, once symptoms appear, death occurs within a year or so in the majority of cases. In aneurysms of the thoracic aorta, for example, the average period of survival after diagnosis has been found to be 6 to 8 months[14]. While life expectancy for abdominal aneurysms, predominantly arteriosclerotic in type, is somewhat better, about a third of the patients die within the first year after diagnosis—mostly from rupture[12]. Rarely even a patient with ruptured abdominal aneurysm will survive, but in the vast majority the condition is rapidly fatal within the first few hours or days. Prognosis in dissecting aneurysms of the aorta is almost as grave as for ruptured aneurysms. Thus, according to the excellent study by Shennan[18] of patients with dissecting aneurysm, death ensued within 24 hours after onset in 58 per cent and in 1 day to 1 week in 26 per cent. Others[15, 20] have reported that about 75 per cent of patients died within 60 days and the remaining 25 per cent developed the chronic or so-called healed form of the disease, and survived 3 months to 8 years. In summary then, dissecting aneurysm may be considered fatal in from 75 to 90 per cent of the cases. On the basis of these data it is apparent that aortic aneurysm compares with other highly lethal diseases in regard to morbidity and threat to life, and an aggressive surgical approach to such lesions is justifiable wherever the general condition of the patient permits.

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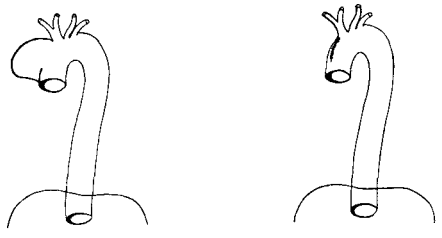
Surgical methods employed until recently, and designed primarily to promote thrombosis within the sac or to reinforce the wall of the aneurysm, have proved generally unsatisfactory and, for the most part, have been discarded. During recent years excisional therapy of aortic aneurysms which provides a direct curative attack has been established as the most effective method for such lesions. Actually the underlying principles of arterial excision were well developed by experimental workers and even advocated and sporadically applied by a few surgeons near the turn of the century. For aortic lesions, however, little consideration was given to the method of excisional therapy at this early date. Tuffier[19], in 1902, occluded the neck of a sacciform aneurysm of the ascending aorta by sutures without excising the sac, but unfortunately the patient died 10 days later from secondary hemorrhage, probably because of gangrene of the sac and infection. Nevertheless, he was convinced of the rationale of aortic aneurysmectomy and recommended the procedure. In 1910, Carrel[1] predicted that on the basis of experimental observations extirpation of aortic aneurysms was rational and believed that aortic repair was feasible under these circumstances, but unfortunately no significant clinical efforts of this type were made. Revival of interest in aortic surgery occurred within the past decade, when Gross[13] and Crafoord and Nylin[7] in 1945 first reported successful excision of a coarctation with end to end anastomosis. Subsequent developments in vascular surgery followed rapidly, and the concept of excision of aortic lesions was extended to aneurysms, as well as obliterative or occlusive lesions. We, like others, began approximately 5 years ago to apply this principle for almost all aortic aneurysms with increasingly gratifying results[2]. This report is concerned with our experience with excisional therapy during the period between July 1951 and Feb. 1, 1956.

Details in the technic of excisional therapy have been described in previous reports[2-4, 6, 9-11] but certain aspects deserve brief consideration. The actual method of excision employed in the individual case depends largely upon the nature and location of the lesion. Tangential excision and lateral aortorrhaphy is employed in sacciform aneurysms, usually syphilitic in origin, where only a portion of the circumference of the vessel is involved by the disease process (fig. 1). After careful isolation of the neck of the aneurysm a long-bladed occluding clamp is tangentially applied following which the sac is evacuated and



21 Patients

Fig. 1. Drawing showing the method of tangential excision of sacciform aneurysms of the aorta with lateral aortorrhaphy.

excised. In most syphilitic aneurysms of this type the adjacent aorta is relatively leathery in consistency and can be sutured without difficulty. This method of repair is particularly suited for aneurysms of the ascending aorta because aortic flow can be maintained continuously during the procedure. Tangential excision also may be used for lesions of the distal aortic arch and descending thoracic aorta in those instances where conditions are favorable, but segmental aortic resection frequently is used even for sacciform aneurysm in this location.

In fusiform aneurysms, either arteriosclerotic or syphilitic in origin, in which the entire circumference of the aorta is involved, segmental resection with restoration of continuity by graft is the procedure of choice (fig. 2). In general this method consists in temporary interruption of aortic flow by cross-clamping proximal and distal to the lesion while the diseased segment is excised and replaced with an aortic homograft. This method was first used successfully in the abdominal aorta where resection of the bifurcation was accomplished with restoration of flow into both common iliac arteries. With increasing experience and later with the development of hypothermia similar procedures may now be successfully performed in the thoracic aorta as high as the origin of the left subclavian artery. The two regions of the aorta presenting the greatest technical problems in application of this method of therapy are the ascending aorta or proximal aortic arch and the proximal abdominal aorta at the level of major

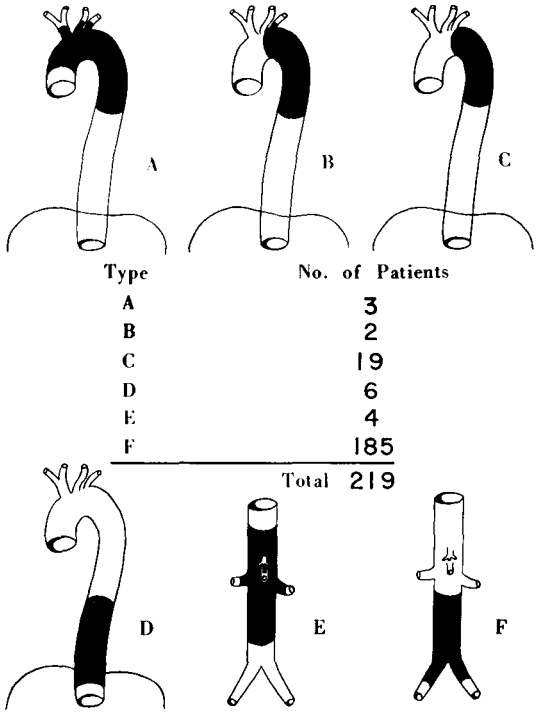


Fig. 2. Drawing showing the method of restoration of aortic continuity after segmental resection for fusiform aneurysms at various levels.

tributaries supplying abdominal viscera. Ischemic injury to organs located distal to the point of temporary aortic occlusion is the major limiting factor in successful application of this technic to lesions of the thoracic and proximal abdominal aorta, and effective control of this problem is crucial in determining success of the operation.

The central nervous system is the most vulnerable tissue to injury from temporary ischemia, and in general, the level and duration of occlusion of the aorta determine the extent and severity of neurologic sequelae. Although the usual safe interval for occlusion of the proximal descending aorta has been estimated to be approximately 15 to 30 minutes, the variation in arterial supply to the cord in addition to other local and systemic factors may lead to paraplegia and even death following briefer periods of occlusion. Fortunately this threat assumes less importance in aneurysms of the terminal thoracic aorta and is almost negligible in abdominal aneurysms if aortic occlusion is not unnecessarily prolonged.

For lesions located in the proximal thoracic aorta measures are employed in all patients to control the threat of ischemic damage to the spinal cord. Technical steps in the operation designed to minimize the period of occlusion are important, and usually the period of occlusion in these cases is less than 1 hour. Other solutions to this problem, including the use of hypothermia and of temporary shunts to conduct aortic flow around the occluded segment, also are employed. Hypothermia by reducing the arterial oxygen requirement of the central nervous system has been demonstrated both experimentally[16, 17] and clinically[5] to prolong the period of safe aortic occlusion. Accordingly, hypothermia is used for aneurysms involving the distal half of the arch and proximal descending thoracic aorta, but for most lesions located distal to the level of the eighth or ninth dorsal vertebra operation is performed at normal body temperature. Hypothermia also exerts a protective influence upon the kidney and liver during temporary arterial occlusion and therefore is employed where the aneurysm involves the proximal abdominal aorta and requires temporary interruption of the corresponding vessels[12].

Temporary external shunts are necessary in resection of fusiform aneurysms located in the ascending aorta or proximal aortic arch where even brief periods of occlusion of the ascending aorta can be rapidly fatal due to severe left ventricular strain and cardiac failure, as well as to cerebral ischemia. Thus, for fusiform aneurysms involving the ascending aorta and arch a temporary shunt is attached to the side of the aorta proximally and distally with branches sutured into the carotid arteries[6]. During the period of aortic occlusion, therefore, the shunt conducts blood to the descending thoracic aorta, and also provides adequate cerebral circulation. Temporary shunts are not used in aneurysms of the descending aorta since hypothermia is considered adequate for this purpose. In 4 cases of thoracoabdominal aneurysm where the celiac axis, renal and superior mesenteric arteries were involved, a shunt was attached to the thoracic and abdominal aorta, proximal and distal to the lesion, thereby significantly reducing the period of total renal ischemia and apparently controlling the ex-

4 Patients

FIG. 3

9 Patients

FIG. 4

Fig. 3. Drawing showing a dissecting aneurysm in which the intimal tear occurred in the ascending aorta and the method of surgical repair.

Fig. 4. Drawing showing a dissecting aneurysm in which the intimal tear occurred in the aorta distal to the aortic arch and the method of repair.

tent of renal insult[11]. The temporary shunts used in these cases are made of compressed polyvinyl Ivalon® sponge in most instances, but heterografts and homografts also are used for this purpose in some instances.

The concept of surgical treatment of dissecting aneurysm is based upon the unique pathogenesis of this type of aneurysm produced by intramural separation of the aortic layers. Degeneration of the medial elements of the aortic wall predisposes to tear or rupture of the intimal coats, occurring usually in the aortic arch just above the aortic valve or in the region of the ligamentum arteriosum or subclavian artery. The forceful stream of blood causes separation of the aortic wall usually in the medial layer which continues circumferentially and may extend throughout the length of the aorta (figs. 3 and 4). Dissection may occur rapidly, resulting in perforation of the outer layer of adventitia into the mediastinum, pleural or peritoneal cavities, or into the pericardium. In some instances the intramural dissection causes compression or shearing off of aortic tributaries. Under these conditions, occlusion of renal arteries may lead to uremia, neurologic signs may occur from spinal cord ischemia, or complete occlusion of the iliac arteries may cause symptoms and signs suggestive of saddle embolus. In those patients fortunate enough to survive dissecting aneurysm re-entry of the intramural passage into the true lumen may be responsible for arrest of the dissecting process. Thus, the surgical procedure which was employed in some of our cases was based upon nature's method of healing, an opening for re-entry of the dissected passage being made at some distal point in the aorta, permitting restoration of peripheral circulation and removing the increasing tension upon the outer wall in order to prevent its rupture (fig. 3). If the origin of the intimal and medial tear is in the ascending aorta or proximal arch a re-entry passage is created at a point distal to the left subclavian artery with obliteration of the false passage below. This is accomplished by

cross-clamping and dividing the aorta, approximating the outer and inner layers in the distal segment and excising a small segment of the inner layer to provide the re-entry passage in the proximal segment. Then end to end anastomosis is done to complete the operative procedure.

In cases in which the dissection begins near the origin of the left subclavian artery a more curative method based upon somewhat the same principle is used, excising that segment of vessel where the dissection originates, obliterating the distal false passage and restoring aortic continuity with a homograft (fig. 4). During the postoperative period efforts to control hypertension are stressed to prevent rupture of the weakened outer wall until it gains adequate support from periaortic fibrous tissue reaction.

Aortic continuity may be restored after segmental resection of the aorta by means of arterial grafts or by synthetic prostheses. During the past 3 years we have used homografts in approximately 400 cases for replacement of aortic segments which were excised for aneurysm or occlusive disease. In these cases both early and late results have been very satisfactory, particularly with lyophilized or freeze-dried grafts. Follow-up studies on many of these patients, including aortography, indicate that there is little tendency to dilatation in the grafts and the histologic appearance remains surprisingly normal for periods more than 3 years[8]. We have also used certain synthetic materials for aortic replacement. Aortic prostheses of orlon cloth, orlon knit and compressed Ivalon® polyvinyl sponge were used in 26 patients. In all but one of these patients where a thoracic replacement was done a bifurcation abdominal prosthesis was used. There were two late complications resulting from use of these synthetic materials. In one an orlon prosthesis eroded the duodenum several months later and in the other infection of an Ivalon® graft led to secondary hemorrhage 2 months later. These materials are somewhat more difficult to use in the aorta from a technical standpoint but may be recommended at present, particularly where homografts are not available.

RESULTS

During the approximate 5 year period included in this report excisional therapy for aortic aneurysms was employed in 253 patients with lesions of the abdominal aorta in 185 and thoracic aorta in 68, the types and location of the lesions indicated in figures 1 to 4. Death occurred within the first weeks of operation in 24 of the former and 23 of the latter with a total hospital mortality rate of 18 per cent. Several factors have been largely responsible for this apparently high operative risk. Perhaps the most obvious is the policy of accepting for operation almost all patients with aneurysm irrespective of advanced age or evidence of cardiac, renal or respiratory insufficiency. This is evident among the abdominal cases, for example, where approximately 30 per cent were more than 70 years old. Thus, in this elderly group fatality was almost double that of the younger patients. Moreover, the risk in hypertensive patients was twice that of the normotensive. Further indication of the significance of cardiovascular and renal disease is obtained from the fact that death in these patients usually was due to these causes.

Still another important factor contributing significantly to the mortality is the presence of rupture of the aneurysm, existing at the time of operation. Among the patients with abdominal aneurysm there were 25 with acute perforation, operation being performed as an emergency with the patients in shock with massive retroperitoneal hemorrhage. Although there were 9 deaths in this group, the salvage of 16 patients or 64 per cent is particularly striking. In spite of the risk of operation under these circumstances, resection of the aneurysm should always be attempted regardless of the apparent hopelessness of the situation. Moreover, operation should not be delayed in order to combat shock in such cases by massive transfusion and preparations should be made for immediate laparotomy. In most of these patients following the application of the proximal occluding clamp immediate improvement occurs and operation is remarkably well tolerated.

In the cases of thoracic aneurysm the operative risk is even higher than for the abdominal lesions. Undoubtedly, application of clamps to the thoracic aorta nearer its point of origin imposes greater strain upon the cardiovascular system in general and subjects the patient to the risk of more extensive injury from temporary interruption of circulation. For example, in this group of patients acute cardiac failure during the first 24 hours after surgery was the commonest cause of death. In aneurysms about the aortic arch and proximal descending aorta neurologic changes, including cord injury, and cerebral damage from ischemia or embolism were serious complications frequently resulting in death. It is significant that in fusiform aneurysms of this region (figs. 2 A-C) the mortality rate was 45 per cent in contrast to a mortality rate of 16 per cent in the distal thoracic aorta (fig. 2 D). In patients undergoing extensive bilateral thoracotomy respiratory complications were often severe requiring tracheostomy and artificial respiration to maintain life in some instances. Many of these patients had tracheobronchial compression and atelectasis at the time of operation.

Results of excisional therapy of dissecting aneurysms of the aorta were most gratifying in that survival and apparent cure of this grave condition were obtained in 10 out of 13 patients. The fact that virtually all of the 206 patients surviving operation were relieved of symptoms and returned to a relatively normal life strengthens our conviction that excisional therapy is the most effective method for aortic aneurysms. The serious nature of the disease itself dictates an increased risk in such operations, but with improvement in surgical technic and with further control of limiting factors still existing the risk of operation will undoubtedly be reduced.

SUMMARY

Aneurysm of the aorta is a serious disease causing distressing symptoms and usually leading to death within a year or 2 after diagnosis. Until recently surgery was unsatisfactory but during the past 5 years gratifying results have been obtained with excisional therapy.

For sacciform aneurysms tangential excision with lateral aortorrhaphy is effective whereas fusiform aneurysms require segmental aortectomy with res-

storation of aortic flow by aortic homograft or synthetic prosthesis. Results of treatment in 219 cases of the former and 37 of the latter are reported and factors influencing operative risk are considered.

Because of the unusual pathologic nature of dissecting aneurysm surgical therapy must be adapted to control the dissecting tendency. If the intimal tear occurs in the ascending aorta a re-entry passage is created in the descending aorta close to the origin of the ligamentum arteriosum. When the intimal tear occurs distal to ligamentum arteriosium this segment of aorta is resected, and a graft is inserted. In both types of operation after the aorta is divided the two layers in the lower segment are sutured together in order to eliminate the extension of the process distally. Results of treatment in 13 patients with dissecting aneurysm with 10 survivors are presented.

ADDENDUM

Recent analysis of patients operated through for aortic aneurysm reveal a total of 366 cases, 98 of which were thoracic and 268 abdominal. Since this report was submitted, aneurysms of the ascending aorta have been resected with segmental replacement by homograft in three cases utilizing the mechanical heart lung for cardiopulmonary by-pass. Temporary extracorporeal aortic by-pass, shunting blood from the left auricle to the abdominal aorta, was used successfully in 2 cases for resection of the descending thoracic aorta for aneurysm.

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